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Buying Beauty: On Prices and Returns in the Art Market

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This paper investigates the price determinants and investment performance of art. We apply a hedonic regression analysis to a new data set of more than one million auction transactions of paintings and works on paper. Based on the resulting price index, we conclude that art has appreciated in value by a moderate 3.97% per year, in real U.S. dollar terms, between 1957 and 2007. This is a performance similar to that of corporate bonds—at much higher risk. A repeat-sales regression on a subset of the data demonstrates the robustness of our index. Next, quantile regressions document larger average price appreciations (and higher volatilities) in more expensive price brackets. We also find variation in historical returns across mediums and movements. Finally, we show that measures of high-income consumer confidence and art market sentiment predict art price trends.

Key words: art; auctions; hedonic regressions; investments; repeat-sales regressions; sentiment
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1. Introduction

Stories about the baffling amounts of money paid for first-tier art frequently entertain newspaper readers around the world. Yet high prices do not necessarily imply high returns. Consider, for example, Claude Monet's *Dans la Prairie*, the star lot of the Impressionist and Modern Art Evening Sale at Christie's London in February 2009. The canvas changed owners for the substantial sum of 11.2 million British pounds and was the top seller in an auction that, according to Studer (2009), "showed that there's plenty of life" in the Impressionist and Modern sector. However, the same painting had been sold twice before in recent history—in June 1988 at Sotheby's London for 14.3 million British pounds and in November 1999 at Sotheby's New York for 15.4 million U.S. dollars (USD). By any standard, the rate of return on the Monet was dismal.

Still, the growth in the number of multimillion-dollar sales, the expansion of the global population of high-net-worth individuals, and the increasing need for portfolio diversification have all brought increased attention to art as an investment in recent years. In turn, the belief in art as a viable alternative asset class has led to the creation of several art funds—not all very successful (Horowitz 2011)—and art market advisory services, which cater to affluent individuals who consider investing in art. The *Wall Street Journal* (2010) recently reported that about 6% of total wealth is held in so-called "passion investments": art, musical instruments, wine, jewelry, antiques, etc. Of all such luxury goods, art is the most likely to be acquired for its potential appreciation in value (Capgemini 2010).

There is a growing academic literature on art investments, but previous studies have utilized relatively small data sets of sales (pairs) at the high end of the market. The resulting indices are subject to a number of estimation issues and selection biases (see §2). This paper therefore uses a comprehensive new data set of nearly 1.1 million auction sales to re-examine the price formation and returns in the art market, over a period from 1957 to 2007.

We perform a hedonic regression analysis that relates transaction prices to a wide range of value-determining characteristics and year effects. Our results show that artist reputation, attribution, signs of authenticity, medium, size, topic, and the timing and location of the sale are significantly correlated with price levels. Based on the regression coefficients on the year dummies in our model, we can build a price index that controls for time variation in the composition of the market. We find that constant-quality art prices increased by a moderate 3.97% in real USD terms on a yearly basis over the 1957–2007 period. Between 1982 and 2007, the geometric average annual real return is 5.19%. For the second half of the 20th century, our estimates are substantially below

those reported by Goetzmann (1993) and Mei and Moses (2002).

Our baseline hedonic index proves robust to alternative specifications and estimation methods. For example, allowing for time variation in the hedonic coefficients does not materially affect our results. Importantly, also applying a repeat-sales regression (RSR) to a subset of our sample leads to nearly identical return estimates for the 1982–2007 period. Quantile hedonic regressions over the same time frame show that historical rates of appreciation vary across the price distribution: the annualized real return at the 95th percentile is almost five percentage points higher than the return at the 5th percentile. Also when using the repeat-sales data (and an ex ante measure of artist reputation), we do not find evidence that portfolios of masterpieces underperform the rest of the market, in contrast to the findings of Pesando (1993) and Mei and Moses (2002). Nevertheless, although high-end art has higher average returns and appreciates faster during boom periods, it seems to fall more in value in downturns. Next, we show that oil paintings and post-war movements have outperformed other art over the last few decades.

Overall, the risk-return profile of art has been inferior to that of financial assets, even before transaction costs, especially in the second half of our time frame. Yet art has outperformed other physical assets, such as gold, commodities, and real estate.

Finally, we examine the determinants of art market returns. We find evidence that (lagged) equity market returns and changes in high-income consumer confidence predict art returns, highlighting the importance of luxury consumption demand. Furthermore, we also document that a novel art market sentiment measure (based on volume and buy-in rates at high-profile auctions and on media reports) forecasts price changes. This suggests that time-varying optimism about the potential of art as an investment can partially explain the existence of art market cycles.

2. Literature on Art Returns

Researchers have used different methodologies to calculate the financial returns on art investments, based on public auction records.[1] Stein (1977) considers the auctioned objects each year as a random sample of the underlying stock of art (by deceased artists) and constructs an index based on the yearly average transaction price. Baumol (1986) and Frey and Pommerehne (1989) calculate the geometric mean return on works that sold at least twice during the considered time frame. Unfortunately, however, these simple methods do not enable the construction of a price index that adjusts for variations in quality. Most recent studies have therefore used either RSRs or hedonic regressions to estimate the price movements of art and other infrequently traded assets (e.g., real estate).

RSRs explicitly control for differences in quality between works by considering only items that have been sold at least twice. The method uses purchase and sale price pairs to estimate the average return of a portfolio of assets in each time period. Pesando (1993), Goetzmann (1993), Mei and Moses (2002), and Pesando and Shum (2008), among others, have applied the methodology to art investments. There are at least two problems with existing RSR studies. First, because art objects trade very infrequently and resales can be hard to identify, only considering repeated transactions decimates any data set to a relatively small number of observations. For example, Mei and Moses (2002) include 4,896 sales pairs over a period of 125 years; Goetzmann et al. (2011) use even fewer sales pairs, although their focus is not on the resulting price index itself. Meese and Wallace (1997) show that the use of such small databases renders RSR estimators sensitive to influential observations. Second, most repeat-sales studies suffer from selection issues. For example, the sample used by Mei and Moses (2002) includes paintings with a first transaction anywhere in the world, but a resale at Sotheby's or Christie's New York—arguably the most expensive sales rooms in the world. Moreover, the initial purchase is identified using the entries in the New York sales catalogues; information on provenance could be more likely to be included when a high price is expected. An index estimated based upon such a sample may thus be biased upward. Other studies, including Goetzmann (1993), have utilized repeat-sales information from the so-called "Reitlinger data"—books with auction price data until the 1960s—which are well known as incomplete and focusing disproportionately on famous artists (Guerzoni 1995).

Hedonic regressions control for quality changes in the transacted goods by attributing implicit prices to their "utility-bearing characteristics" (Rosen 1974). In the often-used time-dummy variant of the hedonic pricing methodology, all available transaction data are pooled, and prices are regressed on a set of value-determining attributes and one or more time dummies. Under the assumption that all omitted characteristics are orthogonal to those included (Meese and Wallace 1997),[2] the coefficients on the time

[1] Art is not only sold at auction, but also privately, for example, through dealers. Total turnover in the art and antiques market is roughly split equally between the two transaction types (McAndrew 2010). However, it is generally accepted that auction prices set a benchmark also used in the private market.

[2] Although there are omitted variables in every model, hedonic pricing is particularly suitable for luxury consumption goods

dummies account for constant-quality price trends over the sample period. Because no information is thrown away prior to the estimation, hedonic regressions make efficient use of available data and may therefore give more reliable estimates of price indices than RSR. One of the key difficulties is the choice of hedonic characteristics (Ashenfelter and Graddy 2003). Observable and easily quantifiable features such as size, medium, and the location of sale have been frequently used (Anderson 1974, Buelens and Ginsburgh 1993, Chanel et al. 1996, Agnello and Pierce 1996), but the literature has failed to systematically include variables that measure artist reputation or the strength of attribution. Also, just like in studies using RSR, the utilized samples have been relatively small and selective. Research has relied on either the problematic Reitlinger data (Buelens and Ginsburgh 1993, Chanel et al. 1996) or on samples of art from a single country (Agnello and Pierce 1996, Renneboog and Van Houtte 2002, Higgs and Worthington 2005).

The estimated returns on art vary with data, methodology, and the time period under consideration (Ashenfelter and Graddy 2003). With respect to paintings, the two most influential studies—which both use the RSR method—report relatively high real returns over the second half of the 20th century. Goetzmann (1993) calculates an average annual real appreciation of 3.8% between 1850 and 1986, but with a "long and strong" bull market, in which annualized returns average around 15%, since 1940. Mei and Moses (2002) report a real return of 4.9% over the period 1875–1999 but a higher annualized return estimate of 8.2% after 1950.[3]

3. Data and Methodology

In this paper, we start from a new and extensive data set to construct a hedonic price index for art. The main advantage of this methodology is that information on all observed transactions can be taken into account. Our model relates the natural logs of real USD prices to year dummies, while controlling for a wide range of hedonic characteristics:

$$\ln P_{kt} = \alpha + \sum_{m=1}^{M} \beta_m X_{mkt} + \sum_{t=1}^{T} \gamma_t D_{kt} + \varepsilon_{kt}, \qquad (1)$$

where P_{kt} represents the price of art object k at time t, X_{mkt} is the value of characteristic m of item k at time t, and D_{kt} is a time dummy variable that equals 1 if object k is sold in period t (and 0 otherwise). The coefficients β_m reflect the attribution of a relative shadow price to each of the m characteristics; the antilogs of the estimates of γ_t can be used to construct an art price index that controls for time variation in the quality of art sold. The value of the hedonic index in year t is then

$$\Pi_t \equiv \exp(\hat{\gamma}_t) \times 100, \qquad (2)$$

with the time dummy coefficient set equal to 0 for the initial, left-out period. This gives an estimated return in year t of

$$r_t \equiv \frac{\Pi_t}{\Pi_{t-1}} - 1. \qquad (3)$$

However, a subtle and often neglected point is that such an index will track the geometric—not the arithmetic—mean of prices over time, because of the log transformation prior to estimation. This is particularly important for our estimation of returns if there is time variation in the (heterogeneity-controlled) dispersion of prices (Silver and Heravi 2007). If we assume that the hedonic regression residuals are normally distributed in each period, then we can correct for this transformation bias by defining corrected index values as follows (Triplett 2004, Silver and Heravi 2007):

$$\Pi_t^* \equiv \exp[\hat{\gamma}_t + \tfrac{1}{2}(\hat{\sigma}_t^2 - \hat{\sigma}_0^2)] \times 100, \qquad (4)$$

where $\hat{\sigma}_0^2$ and $\hat{\sigma}_t^2$ are the estimated variances of the residuals of observations in periods 0 and t, respectively. The corrected return estimate in year t can then be defined as follows:

$$r_t^* \equiv \frac{\Pi_t^*}{\Pi_{t-1}^*} - 1. \qquad (5)$$

We describe our data in §3.1. The hedonic variables that will be used in the estimation of Equation (1) are presented in §3.2.

3.1. Data

We focus on the market for oil paintings and works on paper (i.e., watercolors and drawings), which account for a substantial proportion of all transactions—and about 85% of total turnover—in the art market (Artprice 2006). We start by compiling a list of artists. This selection of artists has to be as exhaustive as possible, so as not to have a bias toward artists that are popular today; therefore, we consult several authoritative art history resources from different time periods. Our artist-selection procedure, of which details can be found in Appendix A, culminates in a list of 10,442 artists. We classify 4,490 of those artists in at least one of the following art movements: Medieval and Renaissance; Baroque; Rococo;

markets, in which a limited number of key characteristics often determine the willingness to pay for an item (e.g., the four Cs of a diamond; Renneboog and Spaenjers 2012). In any case, the omitted variable bias is often small in practice (Butler 1982).

[3] For prints, Pesando and Shum (2008) report a more modest average real return of 1.51% over the period 1977–2004. In general, also studies that use hedonic regressions have found somewhat lower returns than the estimates mentioned above, but to date no exhaustive hedonic analysis has been undertaken.

Neoclassicism; Romanticism; Realism; Impressionism and Symbolism; Fauvism and Expressionism; Cubism, Futurism, and Constructivism; Dada and Surrealism; Abstract Expressionism; Pop; and Minimalism and Contemporary.

We then collect data on all relevant sales by matching our list of names with all artists in the online Art Sales Index database. This resource contains auction records for different types of art. Prices are hammer prices, exclusive of transaction costs. Historically, the Art Sales Index, just like many other databases, has not included buy-ins (i.e., items that do not reach the reserve price and remain unsold).

Although the first sales in the Art Sales Index date from the beginning of the 1920s, data are unavailable or sparse in many years until the second half of the 1950s. Therefore, we start our analysis in 1957, the first year for which we have more than 1,000 observations. (Unfortunately, however, the data coverage is limited for 1963, with only some of the highest priced sales included.) The Art Sales Index only includes London sales until the late 1960s, but it has an exhaustive worldwide coverage after that. The most recent auction records available for this study are from late 2007.

Our final data set consists of 1,088,709 sales; about 60% of these transactions concern oil paintings, with the remainder split roughly evenly between watercolors and drawings. The artist with the highest number of sales (5,405) is Pablo Picasso. The magnitude of our database enables us to draw a complete picture of the price formation and the returns in the art market, in contrast to previous studies that are based on more selective samples.

We translate all nominal prices in our data set to prices in year 2007 USD, using the consumer price index as a measure of inflation. In real terms, the most expensive transaction is *Portrait du Dr. Gachet* by Vincent van Gogh, which sold for 75 million USD in May 1990 at Christie's New York. (In nominal prices, it is *Garçon à la Pipe* by Pablo Picasso, which was auctioned off for 93 million USD in May 2004 at Sotheby's New York.) Such high-profile sales attract ample attention, but the average price is much lower. The mean (respectively, median) sales price over all observations for 2007 is USD 159,354 (respectively, USD 14,775).

Goetzmann (1996) argues that survivorship could cause upward bias in the estimation of art returns, because artists who "fall from fashion" are typically not traded. The impact of this bias on our results should be rather small. First, Goetzmann (1996) finds that the rate of artist obsolescence is relatively low. Second, in contrast to previous work, we do not require a work of art to (re)sell at a large auction house. Our sample thus also includes many sales of less popular artists at smaller auction houses. Finally, pieces that are donated to museums after a substantial increase in an artist's fame—or items that are sold through private transactions in the early part of artists' careers—are not observed at auction either (Goetzmann 1993, Mei and Moses 2002), partially offsetting the upward bias. Nevertheless, our return estimate should probably still be considered as an upper bound on the rate of return, prior to transaction costs, realized by art investors over our time frame.

3.2. Variables

Our hedonic regressions include a number of attributes related to the artist, the work, and the sale. The descriptive statistics for these hedonic variables are presented in Table 1.

First, in addition to artist dummies capturing each artist's uniqueness, we consider the following exogenous reputational measure:

Textbook dummy. We manually check which of our artists were included in several editions of the classic art history textbook *Gardner's Art Through the Ages* (1926, 1959, 1980, 1996, and 2004; Kleiner and Mamiya 2004). In total, 652 of our artists are listed in at least one edition of the book. The dummy variable TEXTBOOK equals 1 if the artist was featured in the edition of—or the last edition prior to—the year of sale.

Two other characteristics related to the artist's career are included in the late-20th-century movement-specific models (see §4.5), but not in our general models, as they could potentially pick up price differences between various eras or movements:

Exhibition dummy. The variable EXHIBITION equals 1 once the artist has been represented at Documenta in Kassel. Inclusion in this prestigious exhibition evidences an artist's rise to fame. In total, 680 of our artists were represented at one of the 11 exhibitions between 1955 and 2002.

Dead artist dummy. It is often assumed that prices for artworks increase after the death of an artist. The dummy variable DECEASED, which equals 1 if the sale occurs subsequent to the artist's death, should capture this effect.

Second, we also consider a range of price-determining variables that capture the attribution and authenticity, the medium, the size, and the subject matter of the work of art:

Attribution dummies. Attribution can be an important factor influencing the price of art objects, especially of older works. Different levels of attribution are used in the auction world: ATTRIBUTED (to), STUDIO (of), CIRCLE (of), SCHOOL (of), AFTER, and (in the) STYLE (of). About 12% of the observations in our sample carry such an attribution.

Authenticity dummies. More than half of the artworks is SIGNED; about one-third is DATED.

Table 1 Descriptive Statistics Hedonic Variables

	N	Mean	SD	0	1
Artist characteristics					
TEXTBOOK	1,088,709	0.1218	0.3271	956,096	132,613
EXHIBITION	1,088,709	0.2118	0.4086	858,118	230,591
DECEASED	1,088,709	0.8810	0.3238	129,574	959,135
Work characteristics					
Attribution dummies					
ATTRIBUTED	1,088,709	0.0435	0.2040	1,041,361	47,348
STUDIO	1,088,709	0.0051	0.0716	1,083,104	5,605
CIRCLE	1,088,709	0.0229	0.1496	1,063,778	24,931
SCHOOL	1,088,709	0.0065	0.0802	1,081,663	7,046
AFTER	1,088,709	0.0101	0.1002	1,077,668	11,041
STYLE	1,088,709	0.0288	0.1671	1,057,407	31,302
Authenticity dummies					
SIGNED	1,088,709	0.5900	0.4918	446,375	642,334
DATED	1,088,709	0.3292	0.4699	730,275	358,434
Medium dummies					
OIL	1,088,709	0.6025	0.4894	432,813	655,896
WATERCOLOR	1,088,709	0.1739	0.3790	899,358	189,351
DRAWING	1,088,709	0.2236	0.4167	845,247	243,462
Size variables					
HEIGHT	1,078,702	20.6597	14.8467		
WIDTH	1,078,549	21.5984	15.8748		
Topic dummies					
STUDY	1,088,709	0.0152	0.1225	1,072,127	16,582
ABSTRACT	1,088,709	0.0255	0.1576	1,060,960	27,749
ANIMALS	1,088,709	0.0108	0.1033	1,076,970	11,739
LANDSCAPE	1,088,709	0.0430	0.2028	1,041,934	46,775
NUDE	1,088,709	0.0082	0.0903	1,079,757	8,952
PEOPLE	1,088,709	0.0377	0.1906	1,047,628	41,081
PORTRAIT	1,088,709	0.0619	0.2410	1,021,273	67,436
RELIGION	1,088,709	0.0161	0.1257	1,071,234	17,475
SELF-PORTRAIT	1,088,709	0.0030	0.0544	1,085,479	3,230
STILL_LIFE	1,088,709	0.0244	0.1543	1,062,130	26,579
UNTITLED	1,088,709	0.0287	0.1670	1,057,438	31,271
URBAN	1,088,709	0.0137	0.1164	1,073,761	14,948
Sale characteristics					
Month dummies					
JANUARY	1,088,709	0.0287	0.1670	1,057,438	31,271
FEBRUARY	1,088,709	0.0450	0.2074	1,039,667	49,042
MARCH	1,088,709	0.0916	0.2884	989,021	99,688
APRIL	1,088,709	0.0862	0.2807	994,864	93,845
MAY	1,088,709	0.1358	0.3426	940,857	147,852
JUNE	1,088,709	0.1389	0.3459	937,442	151,267
JULY	1,088,709	0.0547	0.2275	1,029,109	59,600
AUGUST	1,088,709	0.0132	0.1141	1,074,345	14,364
SEPTEMBER	1,088,709	0.0325	0.1773	1,053,329	35,380
OCTOBER	1,088,709	0.0904	0.2868	990,270	98,439
NOVEMBER	1,088,709	0.1674	0.3733	906,483	182,226
DECEMBER	1,088,709	0.1155	0.3196	962,974	125,735
Sale characteristics					
Auction house dummies					
SOTH_LONDON	1,088,709	0.1220	0.3273	955,868	132,841
SOTH_NY	1,088,709	0.0868	0.2816	994,167	94,542
SOTH_OTHER	1,088,709	0.0553	0.2285	1,028,541	60,168
CHR_LONDON	1,088,709	0.0945	0.2925	985,848	102,861
CHR_NY	1,088,709	0.0621	0.2413	1,021,149	67,560
CHR_OTHER	1,088,709	0.0711	0.2570	1,011,321	77,388
BON_LONDON	1,088,709	0.0106	0.1023	1,077,189	11,520
BON_OTHER	1,088,709	0.0058	0.0759	1,082,400	6,309

Table 1 (Continued)

	N	Mean	SD	0	1
Sale characteristics					
Auction house dummies					
PHIL_LONDON	1,088,709	0.0151	0.1220	1,072,251	16,458
PHIL_OTHER	1,088,709	0.0093	0.0960	1,078,571	10,138
AUCTION_EUROPEAN	1,088,709	0.1364	0.3432	940,173	148,536
AUCTION_AMERICAN	1,088,709	0.0189	0.1361	1,068,160	20,549

Notes. TEXTBOOK is a dummy variable that equals 1 if the artist was included in the last edition of *Gardner's Art Through the Ages* (1926, 1959, 1980, 1996, or 2004; Kleiner and Mamiya 2004) prior to the sale. EXHIBITION is a dummy variable that equals 1 once the artist has exhibited at the Documenta art exhibition in Kassel, Germany. DECEASED equals 1 in case the artist is dead at the time of the sale. The attribution dummies ATTRIBUTED, STUDIO, CIRCLE, SCHOOL, AFTER, and STYLE equal 1 if the auction catalogue identifies the work as being "attributed to" the artist, from the "studio" of that artist, from the "circle" of the artist, from the artist's "school," "after" the artist, or "in the style of" the artist, respectively. The authenticity dummies SIGNED and DATED take the value of 1 if the work carries a signature of the artist or is dated, respectively. The medium dummies OIL, WATERCOLOR, and DRAWING indicate whether the work is an oil painting, a watercolor (or a gouache), or another work on paper. The variables HEIGHT and WIDTH measure the height and the width of the work in inches. The topic dummies are based on the first word(s) of the title of the work (see Appendix B). The month dummies indicate the month of the sale. The auction house dummies SOTH_LONDON, SOTH_NY, SOTH_OTHER, CHR_LONDON, CHR_NY, CHR_OTHER, BON_LONDON, BON_OTHER, PHIL_LONDON, and PHIL_OTHER equal 1 if the sale takes place at Sotheby's London, Sotheby's New York, another branch of Sotheby's, Christie's London, Christie's New York, another branch of Christie's, Bonhams London, another office of Bonhams, Phillips London, or another sales room of Phillips, respectively. AUCTION_EUROPEAN and AUCTION_AMERICAN are dummy variables that equal 1 if the sale takes place at a large Continental European or a large American auction house, respectively (see Appendix C). For each variable, we report the number of observations (*N*), the mean, and the standard deviation (SD). For dummy variables, we also show the number of zeros and ones.

Medium dummies. We introduce dummies for the different medium categories: OIL, WATERCOLOR (including gouaches), and DRAWING.

Size. The height and width in inches are represented by HEIGHT and WIDTH (with squared values HEIGHT_2 and WIDTH_2). The average work has a height and a width of about 20 inches.

Topic dummies. The subject matter can significantly affect the aesthetic appreciation of art objects. We therefore categorize the works in different topic groups based on the first word(s) of the title. We create eleven categories, based on the search strings listed in Appendix B: ABSTRACT, ANIMALS, LANDSCAPE, NUDE, PEOPLE, PORTRAIT, RELIGION, SELF-PORTRAIT, STILL_LIFE, UNTITLED, and URBAN. Furthermore, we create a dummy STUDY that equals 1 if the title contains the words "study" or "etude." The largest categories are portraits and landscapes.

Third, we include dummies that indicate the timing of the sale and the reputation and location of the auction house:

Month dummies. Because important sales are often clustered in time, we include month dummies. The busiest months are May, June, November, and December.

Auction house dummies. We make a distinction between different fine art auction houses that have been important throughout our sample period. For Sotheby's and Christie's, we introduce dummy variables for their London, New York, and other locations (e.g., SOTH_LONDON, SOTH_NY, and SOTH_OTHER). Together, these two institutions are responsible for about half of all sales in our sample. For two other big British auction houses, Bonhams and Phillips, we make a distinction between their London sales rooms and other activities (e.g., BON_LONDON and BON_OTHER). We also create two dummies to account for the sales by important European and American auction houses (AUCTION_EUROPEAN and AUCTION_AMERICAN)—see Appendix C.

4. The Returns on Art

4.1. Baseline Indices

Table 2 shows the parameter estimates of the hedonic variables for our baseline model. Equation (1) is estimated using ordinary least squares (OLS) and the dependent variable is the natural log of the real price in USD. For 1,078,482 sales we have complete information on all hedonic characteristics presented in the previous section. Because of the very large number of observations, nearly all coefficients are statistically highly significant. Hence, we mainly focus on economic significance: Table 2 shows the price impact of each hedonic variable, which can be approximated by taking the exponent of the coefficient and subtracting one. It is important to note that the variables are in most cases picking up otherwise unobservable differences in quality and that the regression coefficients thus reflect correlation instead of causality. For example, works sold at Sotheby's or Christie's mainly have higher prices because of their high attractiveness, not necessarily because of auction house certification.

Table 2 reveals that works are on average priced 13.5% higher after the inclusion of the artist in an important art history reference book. (Remember that the model also includes artist fixed effects.) Also the strength of the attribution has an important effect on the price of an art object. Whenever an attribution dummy comes into play, the price level drops by more than 50%. Not surprisingly, larger discounts are

recorded for works that are "in the style of" or "after" a master than for "attributed" or "studio" works. We also observe that signed and dated works carry higher prices: a signature increases the price by as much as 31% on average, and a date adds almost 19% in value. Works on paper are priced lower than oil paintings, and drawings are less valuable than watercolors. Furthermore, prices increase with size, up to the point that the work becomes too large, as indicated by the negative coefficients on the squared terms. Regarding the topic dummies, there are significant discounts associated with studies and portraits, while self-portraits trade at a premium. The coefficients on our month-of-the-year dummies confirm that the most expensive auctions are clustered at the ends of the spring and the fall. Finally, the highest prices are paid at the main offices of Sotheby's and Christie's.

Table 2 Baseline Hedonic Regression Results

	Coefficient	SD	Price impact (%)
Year dummies	[Included]		
Artist characteristics			
Artist dummies	[Included]		
TEXTBOOK	0.1263	0.0065	13.46
Work characteristics			
Attribution dummies			
ATTRIBUTED	−0.7365	0.0050	−52.12
STUDIO	−0.7977	0.0134	−54.96
CIRCLE	−1.0490	0.0068	−64.97
SCHOOL	−1.4152	0.0120	−75.71
AFTER	−1.8850	0.0104	−84.82
STYLE	−1.5688	0.0064	−79.17
Authenticity dummies			
SIGNED	0.2703	0.0027	31.04
DATED	0.1706	0.0026	18.60
Medium dummies			
OIL	[Left out]		
WATERCOLOR	−0.7144	0.0033	−51.05
DRAWING	−1.1005	0.0030	−66.73
Size variables			
HEIGHT	0.0205	0.0002	2.07
WIDTH	0.0250	0.0002	2.53
HEIGHT_2	−0.0001	0.0000	−0.01
WIDTH_2	−0.0001	0.0000	−0.01
Topic dummies			
STUDY	−0.2049	0.0078	−18.53
ABSTRACT	−0.0780	0.0068	−7.50
ANIMALS	−0.1703	0.0094	−15.66
LANDSCAPE	−0.1320	0.0048	−12.37
NUDE	−0.1645	0.0105	−15.17
PEOPLE	−0.0372	0.0050	−3.65
PORTRAIT	−0.2278	0.0050	−20.37
RELIGION	−0.1114	0.0082	−10.54
SELF-PORTRAIT	0.1202	0.0171	12.77
STILL_LIFE	0.0410	0.0067	4.18
UNTITLED	−0.1639	0.0065	−15.12
URBAN	0.0409	0.0081	4.17
Sale characteristics			
Month dummies			
JANUARY	[Left out]		
FEBRUARY	−0.1209	0.0072	−11.39
MARCH	0.0318	0.0065	3.23
APRIL	0.0859	0.0065	8.97
MAY	0.1325	0.0062	14.16
JUNE	0.1430	0.0063	15.37
JULY	0.0843	0.0070	8.80
AUGUST	−0.0629	0.0101	−6.09
SEPTEMBER	−0.1599	0.0077	−14.78
OCTOBER	0.0007	0.0065	0.07
NOVEMBER	0.1821	0.0061	19.98
DECEMBER	0.1517	0.0064	16.38
Sale characteristics			
Auction house dummies			
SOTH_LONDON	0.6324	0.0037	88.22
SOTH_NY	0.7195	0.0041	105.35
SOTH_OTHER	0.3107	0.0046	36.44
CHR_LONDON	0.6468	0.0039	90.94
CHR_NY	0.6685	0.0046	95.12
CHR_OTHER	0.1540	0.0042	16.65
BON_LONDON	0.1180	0.0094	12.52
BON_OTHER	−0.1193	0.0125	−11.24
PHIL_LONDON	0.2170	0.0079	24.23
PHIL_OTHER	0.1164	0.0099	12.35
AUCTION_EUROPEAN	0.1308	0.0033	13.98
AUCTION_AMERICAN	−0.0968	0.0074	−9.22
N	1,078,482		
R^2	0.6411		

Notes. This table presents the OLS regression results of Equation (1). The dependent variable is the natural log of the price in year 2007 USD. The descriptive statistics for the independent variables are shown in Table 1. For each variable, we report the estimated hedonic coefficient, the standard deviation (SD), and the price impact (i.e., the exponent of the estimated coefficient minus one).

Based on the coefficients on the time dummies and the estimated variance of residuals in each period, we construct both an uncorrected art price index Π and a price index Π^* that corrects for log transformation bias. The results are reported in Table 3; the price levels in 1957 are standardized to 100. As mentioned before, the coverage of the data is very selective for the year 1963, so we geometrically interpolate index values for that year. (Previous studies showed very small price movements in 1963.) Table 3 indicates that the index values have high statistical precision. In most cases, the standard deviation of the regression coefficient is around 0.03, which implies tight confidence intervals around each index value. Figure 1 graphically depicts the evolution of the indices over our time frame and compares them to the evolution of deflated average and median prices in our data set.

The corrected price index in Figure 1 illustrates that, in boom periods, prices can increase very fast: they more than tripled in real terms between 1982 and 1990. The yearly increase in prices between 1985 and 1990 exceeded 23%. However, prices also rapidly decreased after 1990, and no large changes in price levels occurred between the mid-1990s and the first years of the 2000s. In the most recent art boom period of 2002–2007, the annual real price appreciation averaged 13.65%.

The figure documents that an index based on average or median prices would overestimate the

Table 3 Baseline Art Price Indices and Art Returns

Year	Coefficient	SD	$\hat{\sigma}^2$	Π	r (%)	Π^*	r^* (%)
1957			1.1789	100.00		100.00	
1958	−0.0817	0.0402	1.1144	92.16	−7.84	89.23	−10.77
1959	0.2102	0.0384	1.2183	123.39	33.89	125.85	41.03
1960	0.2275	0.0380	1.1131	125.55	1.75	121.48	−3.47
1961	0.3014	0.0382	1.1805	135.18	7.67	135.28	11.36
1962	0.3327	0.0353	1.1744	139.47	3.18	139.16	2.86
1963	—	—	—	140.72	0.89	140.61	1.04
1964	0.3505	0.0355	1.1803	141.97	0.89	142.07	1.04
1965	0.5273	0.0338	1.1770	169.44	19.35	169.27	19.15
1966	0.6390	0.0345	0.9487	189.45	11.81	168.85	−0.25
1967	0.7044	0.0347	0.9466	202.26	6.76	180.07	6.65
1968	0.8423	0.0334	1.0564	232.17	14.79	218.37	21.27
1969	0.8716	0.0335	1.0208	239.08	2.98	220.90	1.16
1970	0.7773	0.0325	0.9335	217.57	−9.00	192.44	−12.88
1971	0.9410	0.0312	0.9100	256.25	17.78	224.01	16.40
1972	1.1224	0.0308	1.0856	307.22	19.89	293.22	30.89
1973	1.3932	0.0304	0.9249	402.77	31.10	354.73	20.98
1974	1.2909	0.0303	0.9030	363.61	−9.72	316.75	−10.71
1975	1.0670	0.0304	0.8847	290.66	−20.06	250.89	−20.79
1976	0.9606	0.0301	0.8685	261.31	−10.10	223.75	−10.82
1977	0.9581	0.0300	0.8779	260.68	−0.24	224.25	0.22
1978	1.0943	0.0300	0.8710	298.69	14.58	256.07	14.19
1979	1.1720	0.0299	0.8397	322.86	8.09	272.49	6.41
1980	1.1763	0.0299	0.8148	324.22	0.42	270.26	−0.82
1981	1.0436	0.0299	0.8329	283.94	−12.43	238.83	−11.63
1982	0.8652	0.0300	0.8095	237.56	−16.34	197.49	−17.31
1983	0.8888	0.0299	0.8137	243.21	2.38	202.62	2.60
1984	0.9058	0.0298	0.8711	247.40	1.72	212.10	4.68
1985	0.9976	0.0298	0.8566	271.17	9.61	230.80	8.82
1986	1.2319	0.0298	0.8567	342.76	26.40	291.75	26.40
1987	1.5505	0.0297	0.8845	471.38	37.53	406.86	39.46
1988	1.7498	0.0297	0.8662	575.35	22.06	492.07	20.94
1989	1.9651	0.0296	0.9220	713.58	24.03	627.57	27.54
1990	2.0252	0.0297	0.9227	757.79	6.20	666.68	6.23
1991	1.6356	0.0298	0.7791	513.24	−32.27	420.25	−36.96
1992	1.5304	0.0298	0.7576	462.02	−9.98	374.26	−10.95
1993	1.3661	0.0298	0.7699	392.01	−15.15	319.51	−14.63
1994	1.3595	0.0297	0.8066	389.41	−0.66	323.27	1.18
1995	1.3727	0.0297	0.8103	394.58	1.33	328.17	1.52
1996	1.3678	0.0297	0.7994	392.66	−0.49	324.78	−1.03
1997	1.3676	0.0297	0.8437	392.60	−0.02	332.02	2.23
1998	1.3954	0.0297	0.8626	403.65	2.82	344.60	3.79
1999	1.4458	0.0297	0.8745	424.54	5.17	364.60	5.80
2000	1.4157	0.0297	0.9165	411.94	−2.97	361.28	−0.91
2001	1.3539	0.0297	0.9354	387.26	−5.99	342.86	−5.10
2002	1.4276	0.0297	0.9354	416.88	7.65	369.08	7.65
2003	1.5405	0.0297	0.8974	466.69	11.95	405.40	9.84
2004	1.6462	0.0297	0.9214	518.74	11.15	456.07	12.50
2005	1.6691	0.0296	0.9769	530.76	2.32	479.76	5.19
2006	1.7724	0.0296	1.0711	588.51	10.88	557.62	16.23
2007	1.9786	0.0299	1.1133	723.27	22.90	699.91	25.52

Notes. This table presents the art price indices and returns for the baseline hedonic regression model detailed in Table 2. For each year, we report the estimated time dummy coefficient, the standard deviation (SD), the estimated variance of the residuals ($\hat{\sigma}^2$), the uncorrected price index and return (Π and r), and the price index and return that are corrected for changes in price dispersion over time (Π^* and r^*) (see §3). Index values for 1963 are geometrically interpolated.

volatility of prices, because of the lack of control for quality differences over time. Indeed, a key contribution of this paper is to disentangle changes in market composition from those in heterogeneity-controlled price levels. (For example, the spikes in average prices in 1989 and 2007 suggest that high-value art is disproportionately put up for sale in boom periods.) At the same time, however, the average and median series serve as a check on the order of magnitude of the overall price appreciation.[4] Figure 1 also illustrates the quantitative importance of the correction for the log transformation; although the end-of-period index values are very similar, we observe marked deviations between Π and Π^* over some periods.

Annualized (i.e., geometric average) returns are reported in Panel A of Table 4. We focus on the corrected price index. On average, art has appreciated at a yearly real rate of 3.97% between 1957 and 2007. Over the last 25 years, the geometric mean real return is somewhat higher (5.19%). The nominal equivalents, obtained by correcting the index for the year-to-year changes in the consumer price index series, are 8.21% (1957–2007) and 8.47% (1982–2007). For the overlapping time intervals, our return estimates are substantially below those reported in Goetzmann (1993) or Mei and Moses (2002). For example, over the period 1957–1999, Mei and Moses (2002) report an annualized nominal return of 12.81%; our index appreciated by 7.59% on an annual basis—a difference of more than 5% per year.

Table 4 also reports standard deviations of the time series of annual returns. For our corrected index, the standard deviation over the full time frame is slightly above 15%. However, we will note that this number underestimates the true riskiness of art investments (see §5).

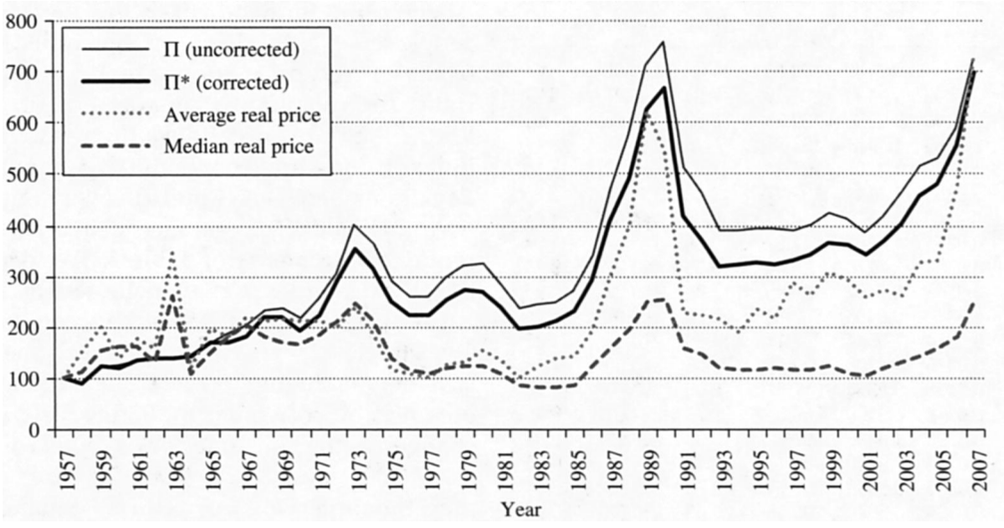
4.2. Robustness Checks

We now check the quantitative robustness of our baseline results. First, we repeat our analysis using a number of different setups: (i) excluding the topic dummies (because these may capture the subject matter rather imprecisely), (ii) excluding the more than 5,000 artists with fewer than 100 sales (because these artists are less liquid), and (iii) excluding Minimalism and Contemporary art (because selection and survivorship issues may be more of a concern for more recent artists). Panel B of Table 4 shows the uncorrected real-return estimates for 1957–2007 and 1982–2007, which can be compared to the performance of price index Π, as shown in Panel A. Our estimates do not change substantially, with annualized price appreciations over the period 1957–2007 that differ by less than 0.05% from those reported earlier.

Second, a potential problem with the hedonic approach is that coefficients are constrained to be stable across the whole sample window. This is a

[4] At least over the last two to three decades, when the coverage of the data set is no longer expanding notably. The positive discrepancy between the average and the median price imply that the auction price distribution is positively skewed. Moreover, the skewness increases in boom periods.

Figure 1 Hedonic Price Indices



Notes. This figure presents the baseline art price indices as detailed in Table 3. Π is the uncorrected price index; Π* corrects for changes in price dispersion over time. The figure also includes indices for the average and median real prices in our sample.

strong assumption, as shadow prices of hedonic characteristics (i.e., tastes) may change over time. An adjacent-period model can mitigate this problem: by dividing the sample in subperiods, it enables the hedonic coefficients to fluctuate (Triplett 2004). We apply this method to our data set by performing a separate hedonic regression for every two consecutive years since 1982 and then chain-linking our returns. We restrict our analysis to the second half of our time frame, because the methodology would underestimate the returns over the full time frame because of the expansion of coverage by the database over the first 20–25 years. The adjacent-year model generates an uncorrected return estimate (4.60%) that is very similar to the one we obtained from the pooled data, lending further support to our benchmark index.

Third, the main advantage of RSR is that it controls for the uniqueness of each work. Also, in contrast to a hedonic price index, it can be thought of as an investable index, at least in theory. Unfortunately, our data set does not uniquely identify each artwork. Therefore, we match sales records using artist name (excluding pupils and followers), size, title (excluding "Untitled" and "Composition"), medium, and the presence of signature and date. Strikingly, this reduces the data set from 1.1 million individual transactions to 30,611 "repeated transactions"—pairs of identical, or at least very similar, items—with a holding period of at least one year. Because an RSR over the full sample would underestimate average returns because of the focus on higher-priced items in the first half of our time frame, we only use the 21,846 sales pairs between 1982 and 2007. This number compares favorably to the size of the databases in previous repeat-sales studies. In line with Goetzmann (1993) and Mei and Moses (2002), we apply a three-stage estimation procedure on our sample of repeat sales, based on Case and Shiller (1987). In a first step, we regress returns on a matrix (containing a row for each item and a column for each time period) with dummy variables indicating the holding period of each item, using OLS. In a second stage, we regress the squared residuals from the first step on an intercept and the time between sales. In a third step, we redo the RSR, using weighted least squares, with the fitted squared residuals as weights. The last line of Panel B of Table 4 shows that, over the time frame under consideration, the RSR implies an average annual increase in the geometric mean price of 4.56%, compared with 4.55% for the (uncorrected) hedonic regression index.[5] The standard deviation is only slightly higher than before. The correlation between the repeat-sales returns and the hedonic returns is 0.98.

4.3. Quantile Regressions

Apart from the existing work on the "masterpiece effect," which examines the question of whether the most expensive art outperforms or underperforms the overall market (e.g., Pesando 1993, Mei and Moses 2002), prior literature has not explored the variation of returns across price brackets. This is surprising, given that the art market is likely to be segmented for a number of reasons. First, art is indivisible, so small investors are generally not able to invest in

[5] Just like the hedonic method, the RSR implies an index that is related to the geometric mean price in each period. Goetzmann (1992) proposes to correct for log transformation bias by adding half of the cross-sectional variance of the returns in each period to the estimated coefficient, where this variance is estimated in the second step of the Case-Shiller method. We compare the pre-correction indices to each other; they should give similar results.

Table 4 Annualized Returns for Baseline Indices, Robustness Checks, and Extensions

		Real returns			
		1957–2007		1982–2007	
	N	Mean (%)	SD (%)	Mean (%)	SD (%)
Panel A: Baseline indices					
Art price index Π	1,078,482	4.04	16.68	4.55	14.39
Art price index Π*	1,078,482	3.97	15.21	5.19	15.31
Panel B: Robustness checks (compare to Π)					
Drop topic dummies	1,078,482	4.02	14.05	4.53	14.39
Exclude artists < 100 sales	935,736	4.04	14.26	4.57	14.69
Exclude Min. and Cont.	1,059,010	4.00	13.95	4.48	14.26
Adjacent-period model	—	—	—	4.60	13.62
Repeat-sales regression (RSR)	21,846 (x2)	—	—	4.56	15.79
Panel C: Quantile regressions					
Q95	862,290	—	—	6.32	18.99
Q75	862,290	—	—	5.77	16.54
Q50	862,290	—	—	4.91	15.11
Q25	862,290	—	—	3.89	13.84
Q05	862,290	—	—	1.35	12.57
Panel D: Trading strategies (compare to RSR)					
"Masterpiece" strategy	1,467 (x2)	—	—	4.81	22.08
"Value" strategy	727 (x2)	—	—	6.16	20.99
Panel E: Indices per medium and per movement					
Oil	650,563	4.63	14.69	5.73	15.39
Watercolor	187,612	3.67	16.38	3.96	14.79
Drawing	240,307	2.51	20.64	4.37	15.22
Medieval and Renaissance	30,806	3.01	27.13	6.44	19.59
Baroque	124,617	4.76	17.69	5.82	12.57
Rococo	30,292	3.69	25.42	5.03	12.15
Neoclassicism	12,601	6.32	45.93	5.36	22.45
Romanticism	41,897	4.28	17.34	4.79	15.24
Realism	60,820	2.57	21.42	4.16	15.46
Impressionism and Symbolism	95,829	4.10	24.01	4.55	16.70
Fauvism and Expressionism	73,543	3.72	22.84	4.90	18.36
Cubism, Futurism, and Constructivism	49,056	5.53	22.40	6.01	20.55
Dada and Surrealism	49,697	5.85	32.32	5.58	19.42
Abstract Expressionism	35,960	—	—	7.78	21.91
Pop	18,924	—	—	10.35	29.33
Minimalism and Contemporary	19,472	—	—	7.07	23.68

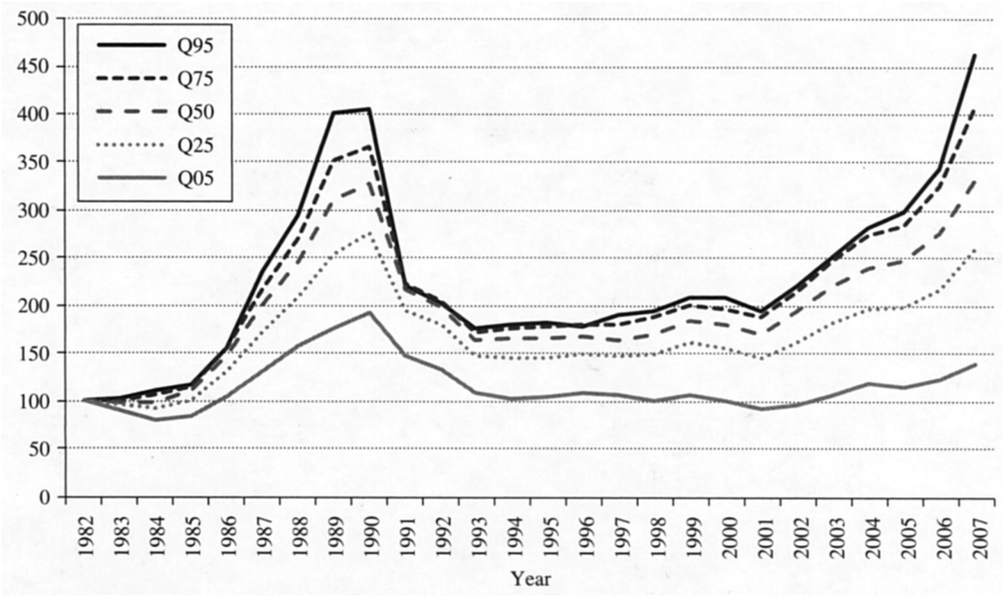
Notes. Panel A presents the annualized (i.e., geometric average) returns and standard deviations (SD) over the periods 1957–2007 and 1982–2007 for the baseline art price indices detailed in Table 3. Panel B shows the results for a number of robustness checks (see §4.2). Panel C repeats the adjacent-period hedonic model using quantile regressions (see §4.3). Panel D presents the RSR results for two different trading strategies (see §4.4). Panel E shows the return estimates (corrected for changes in price dispersion over time) for the different mediums and movements considered in this study (see §4.5).

higher-end works. Second, wealthy individuals may be less tempted to buy in the lower-end of the market, where works do not signal the same social status (Mandel 2009). Third, the more expensive parts of the market may be more prone to speculation. The distribution of returns could thus be skewed over and above a potential masterpiece effect. In such a setting, quantile regressions can be particularly useful (Zietz et al. 2008, Scorcu and Zanola 2011). Although OLS regressions provide estimates for the conditional means only, nonlinear quantile regressions can characterize the entire distribution of the dependent variable (Koenker and Hallock 2001).[6] In our context, this implies that the pricing of hedonic characteristics and the changes in price levels over time are allowed to vary across the distribution of auction prices itself.

We run a quantile variant of our adjacent-period hedonic regression model for every two-year period since 1982 for the following percentiles: 0.95, 0.75, 0.50, 0.25, and 0.05. We split our sample in subperiods to make sure that the quantile-regression coefficients pick up variation in the valuation of hedonic attributes across price brackets rather than across time. The quantile hedonic price indices Q95, Q75, etc. are then constructed by chain-linking the coefficients on the year dummies for the relevant quantiles. We show the results in Panel C of Table 4 and in Figure 2. An interesting pattern emerges. The low performance of Q05 is particularly striking: it has an annual growth rate of only 1.35%, compared with 4.91% for Q50 (i.e., the constant-quality median price level).

[6] Quantile regressions minimize asymmetrically weighted absolute residuals, with the weights defined by the quantile under consideration. At quantiles above (respectively, below) 0.5, more weight is given to positive (respectively, negative) residuals.

Figure 2 Quantile Hedonic Price Indices



Note. This figure presents the art price indices that result from repeating the adjacent-period hedonic model using quantile regressions (see §4.3).

Over the last 25 years, prices have gone up more in the higher price brackets. For example, for Q95, we record an annualized return of 6.32%. Paired-sample t-tests on the return series (not reported) show that the difference in (arithmetic) average return between Q05 and any of the other quantile series is statistically significant at the 0.05 level. The outperformance of the higher quantiles is mainly due to strong price rises in times of increasing demand for art. Vice versa, during the bust of the early 1990s, prices dropped more dramatically for high-value art than for other quantiles. This finding seems in line with "superstar economics."[7] The higher average growth and higher volatility in the upper price range could also be associated with increases in both income inequality (Goetzmann et al. 2011) and the income cyclicality of high-income households (Parker and Vissing-Jorgensen 2010) over our time frame, although we do not formally test these hypotheses in this paper. In contrast, at first sight, the results appear at odds with the finding of Mei and Moses (2002) that masterpieces underperform.

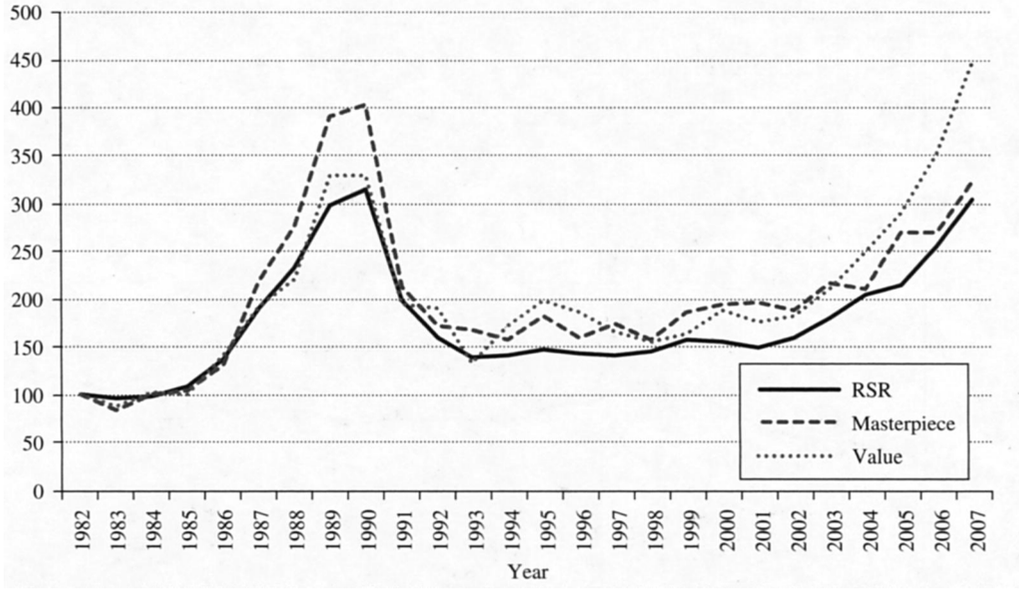
4.4. The Performance of "Masterpiece" and "Value" Portfolios

The quantile-regression results show that prices have generally gone up more for high-value items. To further examine the profitability and riskiness of buying high-end art, we estimate the historical performance of two different investment strategies, based on our repeat-sales data. First, we consider a "masterpiece" strategy: we "buy" in year t all auctioned works by the 100 artists that were most expensive over years $t-1$ and $t-2$ (as measured by the adjacent-period hedonic regression model over those years). In contrast to previous work on the masterpiece effect, we thus do not select works endogenously based on realized transaction prices, but focus on an exogenous price measure on the artist level. Second, we implement a "value" strategy: we buy in year t all observed works by the 100 least expensive artists over $t-1$ and $t-2$ that were nevertheless included in the earlier-mentioned art history textbook at the start of year $t-2$. Such a strategy could exploit fluctuations in taste or a lag in appreciation by the market relative to the recognition of the artist's art-historical significance. (Of course, the items included in this portfolio are in general still expensive, compared to the overall sales distribution.) In both cases, we apply the RSR methodology to estimate returns; in other words, we "sell" whenever the owner sold in reality. The results are shown in Panel D of Table 4 and compared to our earlier constructed RSR index in Figure 3.

We find no evidence of underperformance of a "masterpiece" strategy; this is not inconsistent with our quantile regressions, but stands in contrast to Mei and Moses (2002). The described strategy yields an annualized growth in price levels of 4.81%, compared with 4.56% for our earlier constructed RSR index. The "masterpiece" strategy realized strikingly high returns in the boom in the late 1980s (when indeed blue-chip art was very much in favor) but

[7] In the study by Rosen (1981), a small number of superstars earn large amounts of money, and increases in demand make the earnings distribution ever more skewed. A condition is that there is "imperfect substitution among quality differentiated goods" (p. 846). This is certainly the case in the art market: 10 mediocre works do not add up to a single masterpiece.

Figure 3 Repeat-Sales Price Indices



Note. This figure presents the index that results from applying an RSR to all item pairs that are considered to be repeated transactions (see §4.2) and the art price indices for a "masterpiece" and a "value" trading strategy (see §4.4).

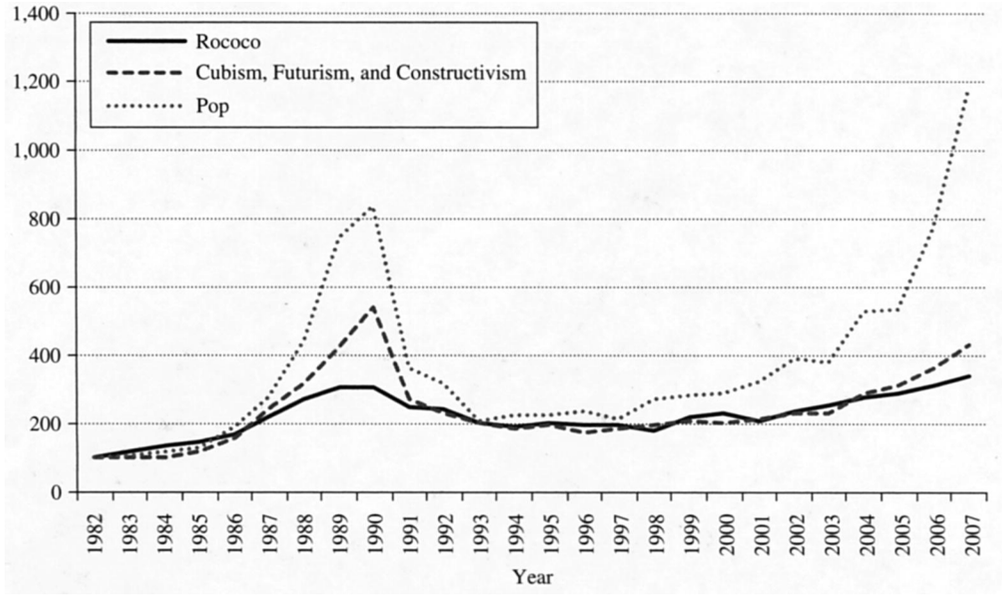
lost much in the subsequent bust. For the "value" strategy, we record an annualized return of 6.16%; it has performed notably well since the mid-2000s. Both high-end strategies thus have final index values above those for the overall sample, although the outperformance is not statistically significant at the traditional levels. The p-value of a t-test on the difference between the "value" returns and the benchmark returns is 0.14.

4.5. Indices per Medium and per Movement

We now return to our baseline hedonic model and repeat the hedonic regression analysis on three complementary subsamples of our data set: oil paintings, watercolors, and drawings. The coefficients on the hedonic variables (not reported) are in line with the previous results. Although the trends are similar across the different types of art, we find faster price increases for oil paintings. In real terms, watercolors and drawings were on average still priced lower in 2007 than in 1989 and 1990. Panel E of Table 4 reports the (corrected) returns over the different time frames. Over the last half century, prices for oil paintings have appreciated at a yearly average real rate of 4.63%, whereas watercolors and drawings have, respectively, increased by 3.67% and 2.51% annually. Oil paintings have strongly and significantly outperformed works on paper in the second half of our time frame—a finding that can be associated with the discrepancies in returns between price categories reported before. The lower performance of art items other than paintings is also consistent with the work of Pesando and Shum (2008), who find an average real return on prints of 1.51% between 1977 and 2004.

Finally, we run a separate hedonic regression for each movement, based on the classification of each artist. We add the variables EXHIBITION and DECEASED to the models for the three most recent art movements (Abstract Expressionism, Pop, and Minimalism and Contemporary). Most artists of these movements have been active over our time frame, which will enable a correct measurement of exhibition and death effects. We find that EXHIBITION is significantly positive in the Abstract Expressionism and Minimalism and Contemporary setups; in the latter model we also observe a clearly positive death effect. In general, the results on the other hedonic characteristics are in line with the earlier findings, although there is some variation in the coefficients on the topic dummies (e.g., a premium is paid for nudes only in Pop) and on the auction house dummies (e.g., auctions at the large continental European houses generate premiums for the earliest art movements). The average yearly real returns for the different art movements since 1957 and since 1982 are also reported in Panel E of Table 4. Since 1957, the indices have increased by between 2.57% and 6.32% on average per year. Between 1982 and 2007, only the post-war art movements Abstract Expressionism, Pop, and Minimalism and Contemporary have shown real price appreciations of more than 7% per annum, on average. However, the standard deviations show that these movements have also been the more volatile ones. Romanticism, Realism, Impressionism and Symbolism, and Fauvism and Expressionism record mean appreciations of less than 5% over the same time frame. The indices for three art movements from

Figure 4 Hedonic Price Indices per Movement



Note. This figure presents the (corrected) hedonic art price indices for three different movements: Rococo; Cubism, Futurism, and Constructivism; and Pop (see §4.5).

different time periods (Rococo; Cubism, Futurism, and Constructivism; and Pop) are plotted in Figure 4 from 1982 onward. The figure confirms that a post-war art movement like Pop has been more profitable—the outperformance is statistically significant at the 0.05 level—but is also more risky.

4.6. Comparison with Prior Literature

Overall, we find substantially lower returns than Goetzmann (1993) and Mei and Moses (2002). Moreover, in contrast to Pesando (1993) and Mei and Moses (2002), we find no evidence that masterpieces underperform. How do we reconcile our findings with the existing literature? First, the higher returns on oil paintings and top-quality art can to some extent explain the difference between the returns on our baseline index and those reported in previous studies. For example, when applying an RSR to resales of oil paintings by textbook-mentioned artists at Sotheby's or Christie's New York, in the spirit of Mei and Moses (2002), we find an annualized nominal return between 1982 and 1999 of 9.27%. Although still below the geometric average return of 10.76% reported by Mei and Moses for the same period, this figure is substantially higher than the 7.05% on our baseline hedonic index.[8]

[8] As mentioned before, Mei and Moses (2002) only consider resales of paintings at Sotheby's or Christie's New York for which the catalogue entry mentions a previous sale. We focus on textbook-mentioned artists, because additional analysis on a small subset of our data suggests that provenance is more frequently included in catalogue entries for works by better-known artists. The RSR estimate reported here is after the standard correction for log transformation proposed by Goetzmann (1992) and also used by Mei and Moses (2002).

Second, Mei and Moses (2002) test the masterpiece effect by estimating the sensitivity of annual returns to purchase prices in an extension of the standard RSR model. When replicating their model on our sample of repeated sales (in unreported analysis), we also find a significantly negative coefficient. Idiosyncratic overbidding and mean reversion can partially rationalize this result when masterpieces are identified endogenously based on transaction prices (Ashenfelter and Graddy 2003). Another problem with the specification put forward by Mei and Moses that can help reconcile our main results with the negative sign on the masterpiece variable is that the highest prices are realized on top-quality art in boom periods—exactly the category of art for which we showed that prices may drop most dramatically afterward. Moreover, when we split our time frame in subperiods, we find a positive sign on the masterpiece variable for boom periods like 1986–1989 or 2002–2007. This finding is in line with our earlier reported findings (see Figure 2).

5. Comparison of Investment Performance and Correlation with Other Asset Classes

We want to compare the performance of art investments to that of other assets. However, we first need to address the underestimation of risk by our hedonic indices. Because our methodology aggregates sales information per calendar year, our returns will suffer from spurious first-order autocorrelation and have understated standard deviations. We can unsmooth our baseline index Π^*, a technique originated in the

Table 5 Art vs. Other Assets

Panel A: Comparison of investment performance

	Real returns					
	1957–2007			1982–2007		
	Mean (%)	SD (%)	Sharpe	Mean (%)	SD (%)	Sharpe
Art	3.97	19.05	0.2000	5.19	18.04	0.2725
T-bills	1.39	2.11	—	1.99	1.88	—
U.S. government bonds	2.68	10.56	0.1853	5.77	9.87	0.4503
DJ corporate bonds	3.97	9.74	0.3443	6.81	7.69	0.7256
Global government bonds	3.07	8.19	0.2641	5.98	7.53	0.5717
S&P 500 stocks	6.63	16.54	0.4106	9.33	15.34	0.5707
Global stocks	6.34	16.16	0.3953	8.91	16.76	0.5039
Gold	2.35	24.19	0.1285	−0.89	14.80	−0.1171
Commodities	3.03	11.40	0.1780	2.06	10.28	0.0511
U.S. real estate	1.06	4.06	−0.0548	2.41	4.73	0.0902

Panel B: Correlations of returns

	Art	T-bills	U.S. government bonds	DJ corporate bonds	Global government bonds	S&P 500 stocks	Global stocks	Gold	Commodities	U.S. real estate
Art	1.00									
T-bills	0.01	1.00								
U.S. government bonds	−0.20	**0.56**	1.00							
DJ corporate bonds	−0.17	**0.58**	**0.90**	1.00						
Global government bonds	−0.10	**0.46**	**0.88**	**0.89**	1.00					
S&P 500 stocks	−0.03	**0.34**	**0.27**	**0.39**	**0.33**	1.00				
Global stocks	0.20	**0.28**	0.18	**0.32**	**0.33**	**0.88**	1.00			
Gold	**0.30**	**−0.54**	−0.18	−0.28	−0.13	−0.28	−0.15	1.00		
Commodities	**0.44**	**−0.41**	−0.26	−0.25	−0.25	−0.15	−0.07	**0.55**	1.00	
U.S. real estate	**0.39**	−0.24	−0.13	−0.13	−0.07	−0.15	0.02	0.24	0.16	1.00

Notes. Panel A displays the geometric mean real returns on art and other assets since 1957 and since 1982. The real returns on art are based on our corrected price index II* and are shown in Table 3. The return data for the financial assets, gold, and commodities come from GFD. Data for U.S. real estate come from Shiller (2009). The panel also includes the standard deviation (SD) of the returns, and the arithmetic Sharpe ratio (i.e., the arithmetic average excess return divided by its standard deviation). The standard deviations for art are based on a desmoothed return series (see §5). The return on T-bills is used as a proxy for the risk-free rate. Panel B shows the pairwise correlations between the returns since 1957. Correlation coefficients that are significantly different from zero at the 0.05 level are displayed in bold.

real estate literature but later also applied to collectibles (e.g., Campbell 2008, Dimson and Spaenjers 2011). Based on the study by Working (1960), we can compute that taking a yearly average of daily prices induces spurious first-order serial correlation in the hedonic coefficients of about 0.25. We therefore re-estimate our standard deviations, removing this spurious autocorrelation from the return series. Over the period 1957–2007, the standard deviation of our unsmoothed art index is now equal to 19.05% (instead of 15.21%). Over the second quarter century, the standard deviation rises less sharply, from 15.31% to 18.04%.[9]

We collect data from Global Financial Data (GFD) on indices measuring total returns on U.S. T-bills, 10-year U.S. government bonds, Dow Jones corporate bonds, the GFD global index for government bonds, S&P 500 stocks, the GFD world index for equity, gold prices, and the CRB commodity price index. We borrow data on residential real estate prices in the United States from Shiller (2009); unfortunately, commercial real estate price indices have been available for shorter time periods. Panel A of Table 5 shows the average yearly real returns and volatilities calculated over the periods 1957–2007 and 1982–2007. The same table also presents the ex post (arithmetic) Sharpe ratios, using the returns on T-bills as the risk-free rate.

Over the longer time frame, the art index clearly underperforms stocks. The S&P 500 and the GFD

[9] Even these new numbers are still a lower estimate of the true riskiness of art investments, for two reasons. First, the standard deviations reported here refer to the aggregate art market; Panel D of Table 4 made clear that, in practice, the volatility of art *portfolios* is likely to be higher. Second, our analysis does not take into account buy-ins. If reserve prices in the art market follow recent sales prices, this implies a return measurement bias when the market reverses (Goetzmann and Peng 2006): returns may be underestimated (respectively, overestimated) in boom (respectively, bust) periods.

global equity index have appreciated at average real rates of 6.63% and 6.34%, respectively, whereas our art index increased by 3.97% annually over the same period. The reward-to-variability, as measured by the Sharpe ratio, is higher for stocks and corporate bonds than for art. The art index has a higher average return since 1957 than both government bond indices, but the Sharpe ratio only surpasses that of U.S. government bonds. Nevertheless, compared with the other tangible assets in Table 5 (gold, commodities, and real estate), art does relatively well. Over the shorter time frame (since 1982), the risk-return profile of art only compares favorably to that of other real asset classes.

Our comparison does not take into account differences in transaction costs, which are high for art investments. For most of our time frame, auction houses charged buyer's premiums and seller's commissions of around 10% (Pesando 1993, Ashenfelter and Graddy 2003). However, in recent years, although important consignors have sometimes been able to obtain lower commission rates, the buyer's premium has grown to around 25% for many smaller purchases. The large transaction costs emphasize the need for long holding periods in collectibles markets (Dimson and Spaenjers 2011). Moreover, art buyers have to take into account storage and insurance costs.

We now turn to the correlations between the asset categories. Panel B of Table 5 shows the correlation matrix of real returns for the 1957–2007 time frame. The correlations between our art index on the one hand and the gold, commodity, and real estate price indices on the other are 0.30 or higher. In contrast, we find very little comovement between art and financial assets. Yet additional analysis shows correlations of art returns with lagged equity returns of 0.34 (S&P stocks) and 0.55 (global stocks). This suggests that wealth effects may drive art prices—something we examine in more depth in the next section.

6. Consumer Confidence, Art Market Sentiment, and the Returns on Art

Art is ultimately a durable luxury consumption good, and consumption indeed seems to dominate the art purchase decision for a representative agent (Mandel 2012). The fundamental value of a work of art can thus be thought of as the present value of all future flows of consumption services. In each period, the market price of the consumption flow will be determined by the strength of demand, because supply is inelastic. The importance of investment income for wealthy households, together with the discretionary nature of luxury consumption, may then induce positive correlation between art prices and financial asset values (Aït-Sahalia et al. 2004). Previous literature (e.g., Hiraki et al. 2009, Goetzmann et al. 2011) has indeed found a strong relation between stock prices and art prices. In line with this work, in column (1) of Table 6, we regress our art returns on same-year and lagged global stock market returns over the period 1981–2007. Below each coefficient, we report Newey-West standard errors that control for heteroskedasticity and autocorrelation up to two lags. Adjusted R-squares are reported at the bottom. The results confirm that stock returns significantly affect art price growth rates.

To further examine the role of consumer demand, we add in column (2) a variable that measures whether high-income consumers think it is a good time to purchase "major household items;" Ludvigson (2004, p. 30) notes that "there is some evidence that consumer confidence surveys reflect expectations of income and non–stock market wealth growth." The information is taken from the University of Michigan's Survey of Consumers, and we use the data for December of the previous year. The measure has been standardized to have zero mean and unit variance. We find that consumer sentiment strongly significantly affects art returns. We also see an increase in adjusted R-squared from 0.33 to 0.49.

The results in columns (1) and (2) of Table 6 highlight the importance of consumption demand. However, they cannot fully explain the pattern of art markets booms and busts that we have witnessed over the last decades. This may be because the fundamental value of art, as defined before, is hard

Table 6 Consumer Confidence, Art Market Sentiment, and the Returns on Art

Dependent variable: *Real returns on art*	(1)	(2)	(3)
Same-year global stock returns	0.1751	0.1325	0.1184
	(0.1050)	(0.0901)	(0.0987)
Previous-year global stock returns	0.5396**	0.4012*	0.2976
	(0.2534)	(0.1941)	(0.2066)
High-income consumer confidence		0.0677***	0.0554**
		(0.0226)	(0.0231)
Art market sentiment			0.0425**
			(0.0175)
N	27	27	27
Adjusted R^2	0.33	0.49	0.52

Notes. This table presents the results of a linear regression of art returns on a number of independent variables over the period 1981–2007. The real returns on art are based on our corrected price index Π^* and are shown in Table 3. Column (1) only includes same-year and lagged global stock returns, from GFD, as independent variables. Column (2) adds (lagged and standardized) data from the University of Michigan's Survey of Consumers on the attitude of high-income (upper third) consumers with respect to the purchase of "major household items." Column (3) adds a newly constructed (lagged and standardized) art market sentiment measure, based on volume and buy-in rates at high-profile auctions, and on media reports (see §6). Below each coefficient, we report Newey-West standard errors that control for heteroskedasticity and autocorrelation up to two lags.

*, **, and *** indicate significance at the 0.10, 0.05, and 0.01 levels, respectively.

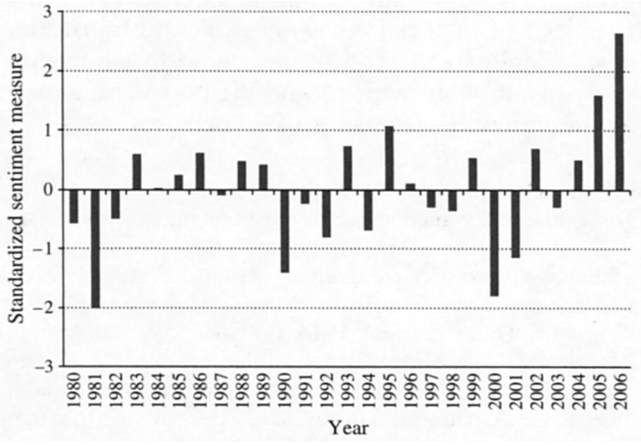
to grasp. Combined with the impossibility of short-selling, this uncertainty implies a potential role for art buyer sentiment, which could be defined as unjustified optimism (or pessimism) about future resale values. Furthermore, because auctions are held infrequently, sentiment may only slowly exert pressure on observed aggregate price levels. We thus expect high sentiment to be followed by price appreciations—at least in the short run—rather than by low returns, as is the case in more liquid financial asset markets (Baker and Wurgler 2006).

We propose three proxies for art market sentiment that can be measured by the end of each year (so that they can be related to price levels in the year starting immediately after). A first factor is the year-on-year change in fourth-quarter sales volume at Sotheby's and Christie's (London). Baker and Stein (2004) argue that in markets with short-sale constraints liquidity can proxy for sentiment. Moreover, they suggest that the "liquidity-as-sentiment approach" is particularly relevant for "real" asset markets. Our second variable equals the rate of items sold (and thus not bought in) at the Impressionist and/or Modern art evening auctions in the fall of each year (since 1980) in New York. These high-profile auctions are considered a barometer for the market, and buy-ins at these sales are widely commented on in the press. We proxy for the sales rates by dividing the number of observed transactions by the maximum lot number for each auction. For our third proxy, we turn to the historical archives of the *Economist*. We look up all articles dated between 1980 and 2006 that mention "art market," "art prices," or "art auctions." We read each article to verify that it is indeed about the state of the art market or about art investment. We then analyze the content of each of the 56 selected articles using a software package called General Inquirer. General Inquirer counts the number of words belonging to certain categories in a text; it is used by Tetlock (2007) in his analysis of the *Wall Street Journal* columns. In each year, our measure of sentiment is the relative use of "positive outlook" versus "negative outlook" words in the last article of the year, using the built-in dictionaries of the software.

Our main sentiment measure is then the first principal component of these three sentiment proxies (which have positive pairwise correlations of between 0.3 and 0.4). Applying a principal components procedure reduces the idiosyncratic noise in each individual measure (Baker and Wurgler 2006). We show the evolution of our standardized sentiment measure since 1980 in Figure 5. Sentiment was negative in the early 1980s, 1990s, and 2000s, and generally positive in the second half of the 1980s and the mid-2000s.

In column (3) of Table 6, we regress the returns on art on the lagged sentiment measure, controlling for same-year and lagged global equity returns and the lagged consumer confidence measure, over the period 1981–2007. The lagged stock return variable is still positive but loses significance at the traditional levels. In line with expectations, we find a positive impact of art market sentiment that is statistically significant at the 0.05 level. This strongly suggests that time-varying optimism about art investment impacts art pricing.[10] Unreported analysis shows that Pop and Minimalism and Contemporary art, which may be harder to value, are more sensitive to changes in art buyer sentiment.

Figure 5 Art Market Sentiment



Notes. This figure presents the end-of-year values for the art market sentiment measure used in this study. It is based on volume and buy-in rates at high-profile auctions and on media reports (see §6). It is standardized to have zero mean and unit variance.

7. Conclusion

Many collectors are acutely attuned to the financial value of their assets (Burton and Jacobsen 1999). Moreover, investors are increasingly turning to collectibles markets to diversify their portfolios. This underlines the importance of an accurate measure of the financial returns to art. Therefore, we have investigated the price determinants and historical investment performance of art by applying an extensive hedonic regression framework to a data set of more than one million paintings and works on paper. Our hedonic art price index indicates that art prices have increased by a moderate 3.97% annually in real USD terms between 1957 and 2007. This return estimate is lower than that reported in previous papers that used smaller samples of high-quality paintings sold at top auction houses. Moreover, we document larger price appreciations at the upper end of the market and variation in

[10] Additionally controlling for global gross domestic product growth, changes in top incomes (using updated U.S. data from Piketty and Saez 2003), real interest rates, or equity market sentiment (Baker and Wurgler 2006) does not materially affect our results.

average returns across mediums and movements. In general, art's risk-return profile is much less attractive than that of financial assets, even before transaction costs. Finally, regression results show that both luxury consumption demand and art market sentiment are important determinants of art price cycles.

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Appendix A. Compilation of List of Artists

We start by consulting Grove Art Online, an online database published by Oxford University Press. We select all 9,775 individual artists from the categories "graphic arts," "painting and drawing," and "printmaking." We subsequently expand our set of artists by means of another online database, Artcyclopedia.com. This raises the number of artists to 10,211.

We then establish a list of 13 art movements: Medieval and Renaissance; Baroque; Rococo; Neoclassicism; Romanticism; Realism; Impressionism and Symbolism; Fauvism and Expressionism; Cubism, Futurism, and Constructivism; Dada and Surrealism; Abstract Expressionism; Pop; and Minimalism and Contemporary. When possible, we classify our artists into one of these categories, based on the "Styles and Cultures" from Grove Art Online and "Art Movements" of Artcyclopedia. We can put 4,132 artists into at least one art movement.

Next, we expand our data set in two more ways, to correct for the possible underrepresentation of modern and contemporary art. We compare the index of the influential book *Modern Art* (Britt 1989) to our data set and add 62 modern artists to our list (with classification). The book also enables us to assign another 87 artists not yet classified to a specific art movement. Next, to have a representative and up-to-date sample of contemporary artists, we consult the entry "List of contemporary artists" on Wikipedia (accessed April 15, 2008). We can add 169 artists, bringing our list to 10,442 artists in total; 40 other artists can now be classified in Minimalism and Contemporary.

Finally, we check for pseudonyms and different spellings of all artists' names.

Appendix B. Titles and Topics

We use the first word(s) of the title to classify works in topic categories. Most titles in our database are in English, but we also include French keywords in our analysis. We avoid search strings that can be used in different contexts. Sometimes we only search for titles no longer than one word or in which the word is followed by a space (e.g., "cat_") to avoid misclassifications caused by longer words with identical first characters (e.g., "catholic").

These are the topic categories, along with their search strings: ABSTRACT ("abstract," "composition"); ANIMALS ("horse," "cheval," "chevaux," "cow_," "cows," "vache," "cattle," "cat_," "cats," "chat_," "dog_," "dogs," "chien," "sheep," "mouton," "bird," "oiseau"); LANDSCAPE ("landscape," "country landscape," "coastal landscape," "paysage," "seascape," "sea_," "mer_," "mountain," "river," "riviere," "lake," "lac_," "valley," "vallee"); NUDE ("nude," "nu_," "nue_"); PEOPLE ("people," "personnage," "family," "famille," "boy," "garcon," "girl," "fille," "man_," "men_," "homme," "woman," "women," "femme," "child," "enfant," "couple," "mother," "mere_," "father," "pere_," "lady," "dame"); PORTRAIT ("portrait"); RELIGION ("jesus," "christ_," "apostle," "ange_," "angel," "saint_," "madonna," "holy_," "mary magdalene," "annunciation," "annonciation," "adoration," "adam and eve," "adam et eve," "crucifixion," "last supper"); SELF-PORTRAIT ("self-portrait," "self portrait," "auto-portrait," "autoportrait"); STILL_LIFE ("still life," "nature morte," "bouquet"); UNTITLED ("untitled," "sans titre"); and URBAN ("city," "ville," "town," "village," "street," "rue," "market," "marche," "harbour," "port_," "paris," "london," "londres," "new york," "amsterdam," "rome_," "venice," "venise").

Appendix C. Important European and American Auction Houses

The AUCTION_EUROPEAN category includes all sales by Lyon and Turnbull (Scotland); Francis Briest/Artcurial Briest (France); Ader, Picard, and Tajan/Ader and Tajan/Tajan (France); Bruun Rasmussen (Denmark); Dorotheum (Austria); Koller (Switzerland); Lempertz (Germany); Neumeister (Germany); Finarte (Italy); Bukowskis (Sweden); and Stockholms Auktionsverk (Sweden). The AUCTION_AMERICAN category includes all sales by Butterfields (until 2002), Swann Auction Galleries, Skinner, Doyle New York, Freeman's, and Leslie Hindman.

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